Approaches for State Event Handling using Simulation Algorithm and via Model Description

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This Paper deals with state events of hybrid systems and their handling in context of simulation and in context of modelling. One point of view is the algorithmic point to implement the handling of state events of a certain model via the simulation algorithm. The other way would be to adapt the model in this way that the handling of the event can be done more easily. These considerations are related to the relationship between the abstract mathematical model and the implementation in a simulation environment, the simulation model. The influence of the aspects of the implementation in the simulation environment on the process to derive the mathematical description has to be considered also regarding the handling of state events.
In the following paper some theoretical considerations are presented and an electrical circuit is used to illustrate the concepts.

1 Introduction

State event handling describes the process of finding, administrating and executing a state transition in a hybrid model structure. In the following subsection a short definition of hybrid model structure and an introduction in these three processes related to state event handling will be given.

Due to the definition of hybrid models the discrete states of this finite automaton are related to a continuous dynamical system and the transitions of the discrete system have to be connected to the continuous systems. This leads to the illustration of the hybrid automaton depicted in Figure 1.

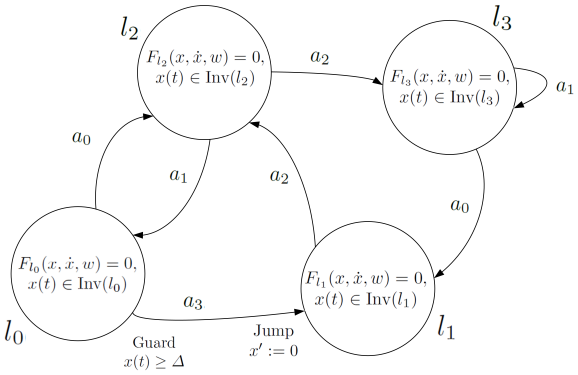

Figure 1: Hybrid model structure represented by a hybrid automata, here illustrated with 4 nodes

2 State Event Modelling

The mathematical definition of events is done by using theory of graphs. For system simulation a reformulation is needed to implement the finding and handling of those state events.

Assume the simulator environment to start in a fixed state the numerical simulation. This assumption is fulfilled if an initial state for the simulation is provided. Thus the simulation starts for a fixed $l \in L$ and therefore with a fixed DAE system F_l. For better handling of the DAE in a certain simulation environment the

abstract function F is distributed in an algebraic and a differential part. Instead of a function F two functions $f\colon \mathbb{R}^n \times \mathbb{R}^q \to \mathbb{R}^n$ and $g\colon \mathbb{R}^n \times \mathbb{R}^q \to \mathbb{R}^k$ are defined. Additionally an initial value $x_0 \in \mathbb{R}^n$ is given, to formulate the DAE system as

$$\begin{aligned} \dot{x} &= f(x,w), x(t_0) = x_0 \\ g(x,w) &= 0 \end{aligned} \tag{1}$$

3 State Event Handling in a Simulation Environment

In this section state event handling is observed from a simulation point of view. It will be focused on the structure and the duties of the simulation environment. The subsection will outline how traditional simulation environments are structured and give approaches for new architecture of simulation algorithms.

In the previous subsection the mathematical environment for a numerical simulation is introduced. A classical simulation environment has to deal with these needs and provide numerical algorithms to handle the involved equations and requirements for a proper simulation. The structure for a simulation algorithm is edited in Figure 2.

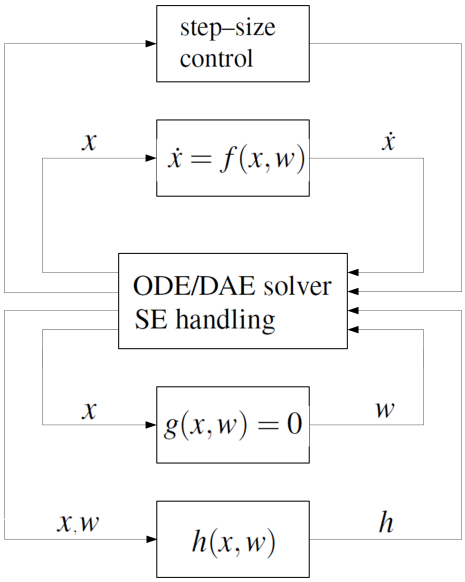

Figure 2: Structure of the numerical simulation of hybrid systems

In Figure 2 the classical structure to manage various hybrid models is illustrated. However, the aim of this paper is to observe model structures which allow a reformulation and in best case a simplification of the structure for a simulation environment.

4 Case Study: Oscillating Circuit with a Diode

One suitable example to investigate this adaption of model structure is a oscillation circuit with a diode. The diode provides the algebraic equation whereby the oscillating circuit supplies a differential equation. The circuit is illustrated in Figure 3.

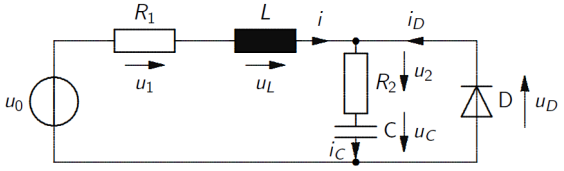

Figure 3: Oscillating circuit with diode

On this example some different approaches will be given to simulate a hybrid system. The classical simulation approach will be discussed and also the adaption of some model attributes to find simpler structures for simulation.

References

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[2] A. Körner, F. Breitenecker, N. Popper. *About an Alternative Method of Numerical Iteration for State Event Finding and Handling in System Simulation of Hybrid Dynamical Systems*, UKSIM – AMSS 15th International Conference on Modellng and Simulation, in Cambridge, UK, p. 390 – 395, 2013.